



(19) Europäisches Patentamt
 European Patent Office
 Office européen des brevets



(11) Publication number:

0 580 980 A1

(12)

EUROPEAN PATENT APPLICATION

(21) Application number: 93108329.9

(51) Int. Cl. 5: H01L 21/00

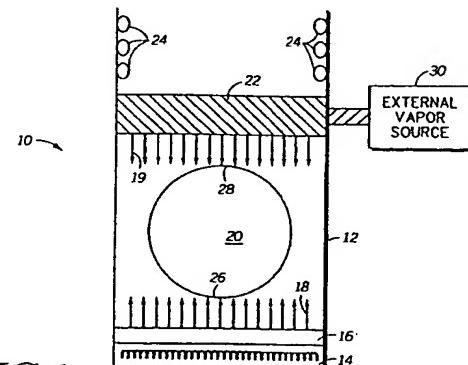
(22) Date of filing: 24.05.93

(30) Priority: 27.07.92 US 920074

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(54) A method for vapor drying.

(57) A multi-directional flow of isopropyl alcohol vapor is used to uniformly dry a semiconductor substrate. In one embodiment of the invention, isopropyl alcohol vapor (19), which is generated by an external vapor source (30), is injected into the vapor drying system at a location near the top portion (28) of the semiconductor substrate (20), while internally generated isopropyl alcohol vapors (18) are directed toward the bottom portion (26) of the semiconductor substrate (20). Therefore, both the top (28) and the bottom (26) portions of the semiconductor substrate (20) are dried at approximately the same time.

**FIG.1**

Field of the Invention

This invention relates generally to vapor drying, and more specifically to the vapor drying of semiconductor substrates.

Background of the Invention

Vapor drying of semiconductor substrates with isopropyl alcohol (IPA) is widely used in the semiconductor industry. In a typical IPA vapor dryer, semiconductor substrates, wet with deionized water, are introduced into a quartz tank containing a cloud of vaporized IPA. The substrates are typically oriented vertically, in a front-to-back relationship. A resistive heater, mounted to the bottom of the quartz tank, is used to heat a reservoir of liquefied IPA and thus generate the IPA vapor cloud. When the warm IPA vapor comes into contact with the cool semiconductor substrates, IPA condenses out on the substrates and forms an azeotropic mixture with the de-ionized water. The azeotropic mixture has a reduced surface tension that allows it to flow off the substrates, and thus remove de-ionized water from the semiconductor substrates. Unfortunately, the semiconductor substrates are not always adequately dried by this process.

The introduction of the wet semiconductor substrates into the quartz tank causes the IPA vapor cloud to collapse or reequilibrate through condensation. Naturally, the IPA vapor cloud is restored first at the bottom of the quartz tank, which is closest to the resistive heat source. Consequently, the azeotropic mixture, which is essential to the drying process, is formed first on those portions of the semiconductor substrate that are located near the bottom of the tank. The azeotropic mixture progresses upward on the substrates, in tandem with the restored IPA vapor cloud. Thus the semiconductor substrates are dried in a bottom to top manner. The restored IPA vapor cloud, however, does not always come into contact with the de-ionized water on the upper portions of the semiconductor substrates, and subsequently form an azeotropic mixture, before the de-ionized water evaporates, forming water spots on the upper portions of the semiconductor substrate. These water spots negatively affect semiconductor device yields and reliability. Additionally, this problem is aggravated by the ever increasing size of semiconductor substrates. Accordingly, a need exists for an IPA vapor drying process that uniformly and reproducibly dries semiconductor substrates, independent of their size.

Summary of the Invention

The previously mentioned problems with existing vapor drying processes are overcome by the present invention. In one embodiment of the invention, an object is vapor dried by placing the object within a tank. The object has a top and a bottom. The object is exposed to a vapor of a drying medium. The vapor of the drying medium is directed toward both the top and the bottom of the object. The vapor of the drying medium condenses on and drips from the bottom of the object, carrying away another liquid that was present on the object.

These and other features, and advantages, will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings. It is important to point out that the illustrations may not necessarily be drawn to scale, and that there may be other embodiments of the present invention that are not specifically illustrated.

Brief Description of the Drawings

FIG. 1 illustrates, in cross-section, a vapor drying system suitable for implementing a process in accordance with one embodiment of the invention.

FIG. 2 illustrates, in cross-section, a vapor drying system suitable for implementing a process in accordance with another embodiment of the invention.

Detailed Description of a Preferred Embodiment

Shown in FIG. 1 is a portion 10 of a vapor drying system comprising a quartz tank 12, a resistive heater 14, a liquefied drying medium 16, drying medium vapors 18 and 19, a semiconductor substrate 20, a vapor manifold 22, cooling coils 24, and an external vapor source 30. Liquefied drying medium 16 is preferably ultra pure isopropyl alcohol. A vapor drying process in accordance with one embodiment of the invention entails the following steps. A semiconductor substrate 20, which is wet with a liquid, is placed vertically into quartz tank 12. Liquefied drying medium 16, which is lying at the bottom surface of quartz tank 12, is heated by resistive heater 14 such that it boils and generates drying medium vapors 18 that are directed toward the bottom portion 26 of semiconductor substrate 20. Additionally, drying medium vapors 19 generated by external vapor source 30 are injected into manifold 22 and directed toward the top portion 28 of semiconductor substrate 20. Drying medium vapors 18 and 19 condense on semiconductor substrate 20 and form an azeotropic mixture with the liquid originally present on semi-

conductor substrate 20. The azeotropic mixture drips from the bottom portion 26 of semiconductor substrate 20 and is carried to a drain, removing the liquid that was originally present on semiconductor substrate 20. When drying medium vapors 18 and 19 no longer condense on semiconductor substrate 20, then semiconductor substrate 20 is removed from the vapor drying system.

Shown in FIG. 2 is a portion 40 of a vapor drying system comprising a quartz tank 42, a resistive heater 44, a liquefied drying medium 46, drying medium vapors 48, a semiconductor substrate 50, cooling coils 54, and a perforated quartz insert 52. Liquefied drying medium 46 is preferably ultra pure isopropyl alcohol. A vapor drying process in accordance with a second embodiment of the invention entails the following steps. A semiconductor substrate 50, which is wet with a liquid, is placed vertically into quartz tank 42 and within perforated quartz insert 52. Liquefied drying medium 46, which is lying at the bottom surface of quartz tank 42, is heated by resistive heater 44 such that it boils and generates drying medium vapors 48. Drying medium vapors 48 are guided by perforated quartz insert 52 such that the vapor flow is directed toward both the bottom portion 56 and the top portion 58 of semiconductor substrate 50, as shown in FIG. 2. The bottom portion of perforated quartz insert 52 is not perforated so that drying medium vapor 48 is forced to move upward and is channeled around semiconductor substrate 50. Drying medium vapors 48 condense on semiconductor substrate 50 and form an azeotropic mixture with the liquid originally present on semiconductor substrate 50. The azeotropic mixture drips from the bottom portion 56 of semiconductor substrate 50 and is carried to a drain, removing the liquid that was originally present on semiconductor substrate 50. When drying medium vapors 48 no longer condense on semiconductor substrate 50, then semiconductor substrate 50 is removed from the vapor drying system. The foregoing description and illustrations contained herein demonstrate many of the advantages associated with the present invention. One advantage is that vapor from the drying medium contacts both the upper and lower portions of the semiconductor substrate nearly simultaneously. Consequently, vapor condensation and the subsequent formation of the azeotropic mixture occurs rapidly on both the upper and lower portions of the semiconductor substrate at essentially the same time. Thus, the entire semiconductor substrate is quickly covered by the azeotropic mixture, which is essential to the drying process, and the semiconductor substrate is uniformly dried. Moreover, not only does this multi-directional drying process allow large semiconductor substrates to be dried, but it also minimizes the

time required to dry them.

Thus it is apparent that there has been provided, in accordance with the invention, a method for vapor drying that fully meets the need and advantages set forth previously. Although the invention has been described and illustrated with reference to specific embodiments thereof, it is not intended that the invention be limited to these illustrative embodiments. Those skilled in the art will recognize that modifications and variations can be made without departing from the spirit of the invention. For example, vapor, which is generated externally, could also be injected at multiple locations around the semiconductor substrate, such as near the top and bottom of the semiconductor substrate and along the walls of the quartz tank. In addition, the invention is not limited to the materials specifically described. Although preferred materials have been recited it is envisioned that numerous materials may be suitable for the different elements of the present invention. For example, drying mediums other than IPA can be used and objects other than semiconductor substrates could be dried. Therefore, it is intended that this invention encompass all such variations and modifications as fall within the scope of the appended claims.

Claims

1. A method for vapor drying comprising the steps of:
 - providing a tank (12, 42), the tank having a bottom surface;
 - providing an object (20, 50), the object having a liquid present thereon, and having a top portion (28, 58) and a bottom portion (26, 56) and a major surface;
 - placing the object (20, 50) within the tank (12, 42) such that the major surface of the object (20, 50) is nearly perpendicular to the bottom surface of the tank (12, 42);
 - exposing the object (20, 50) to a multi-directional vapor (19, 18, 48) flow of a drying medium such that the bottom portion (26, 56) and the top portion (28, 58) are exposed to the vapor (19, 18, 48) nearly simultaneously; and
 - condensing the vapor (19, 18, 48) on the top portion (28, 58) and the bottom portion (26, 56) of the object (20, 50) to remove the liquid from the object.
2. The method of claim 1 wherein the step of exposing the object (20, 50) to the multi-directional vapor (19, 18, 48) flow of the drying medium is further characterized as using a perforated insert (52) to direct the flow of the vapor.

3. The method of claim 1 wherein the step of exposing the object (20, 50) to the multi-directional vapor (19, 18, 48) flow of the drying medium is further characterized as injecting the vapor of the drying medium into the tank. 5
4. The method of claim 1 wherein the step of exposing the object (20, 50) to the multi-directional vapor (19, 18, 48) flow of the drying medium is further characterized as exposing the object (20, 50) to an isopropyl alcohol vapor. 10
5. A method for vapor drying comprising the steps of:
 providing a tank (12), the tank having a bottom surface; 15
 providing a semiconductor substrate (20), the semiconductor substrate having a liquid present thereon, and having a top portion (28) and a bottom portion (26);
 placing the semiconductor substrate (20) within the tank (12);
 injecting an externally generated isopropyl alcohol vapor (19) into the tank (12);
 condensing the isopropyl alcohol vapor (19) on the semiconductor substrate (20) to remove the liquid from the semiconductor substrate. 20
6. The method of claim 5 wherein the step of injecting the externally generated isopropyl alcohol vapor (19) into the tank (12) is further characterized as injecting the externally generated isopropyl alcohol vapor at a first location near the top portion (28) of the semiconductor substrate (20). 25
7. The method of claim 5 further comprising the step of:
 providing a source of liquid isopropyl alcohol (16) at the bottom surface of the tank (12). 30
8. The method of claim 7 further comprising the step of:
 heating the source of liquid isopropyl alcohol (16) to generate isopropyl alcohol vapor (18) at a second location near the bottom portion (26) of the semiconductor substrate (20). 35
9. A method for vapor drying comprising the steps of:
 providing a tank (42), the tank having a bottom surface; 40
 providing a semiconductor substrate (50), the semiconductor substrate having a liquid present thereon, and having a top portion (58) and a bottom portion (56) and a major surface; 45
 placing the semiconductor substrate (50) within the tank (42) such that the major surface of the semiconductor substrate (50) is nearly perpendicular to the bottom surface of the tank (42);
 generating an isopropyl alcohol vapor (48) near the bottom surface of the tank (42);
 channeling the isopropyl alcohol vapor (48) uniformly around the semiconductor substrate (50) such that the bottom portion (56) and the top portion (58) of the semiconductor substrate (50) are exposed to the isopropyl alcohol vapor (48) nearly simultaneously; and
 condensing the isopropyl alcohol vapor (48) on the top portion (58) and the bottom portion (56) of the semiconductor substrate (50) to remove the liquid from the semiconductor substrate. 50
10. The method of claim 9 wherein the step of channeling the isopropyl alcohol vapor (48) is further characterized as using a perforated insert (52) to channel the isopropyl alcohol vapor (48) uniformly around the semiconductor substrate (50). 55

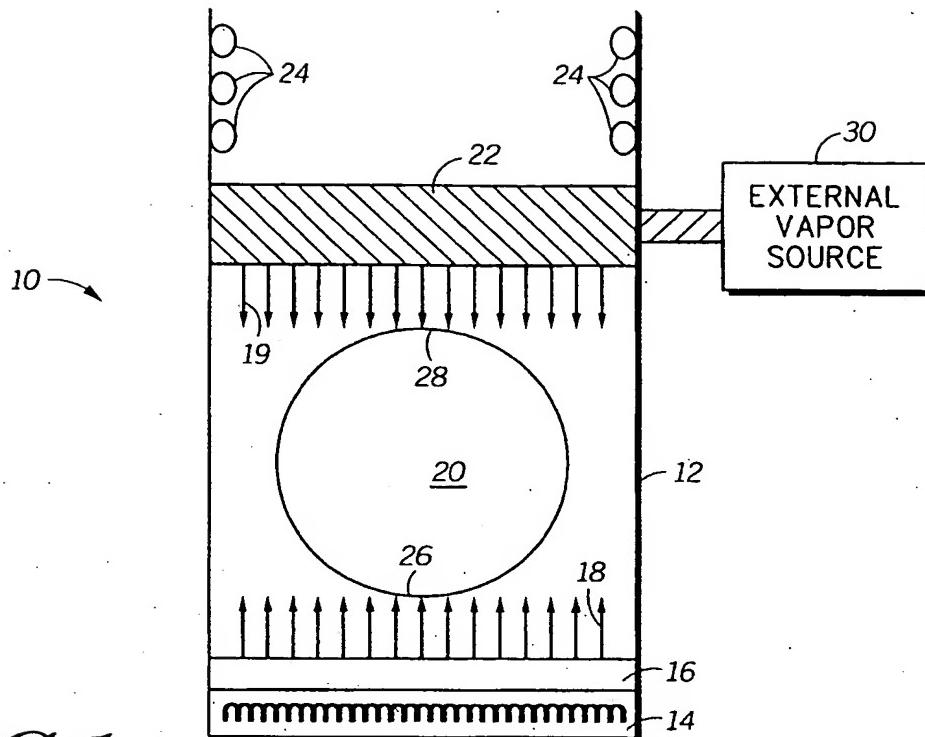


FIG. 1

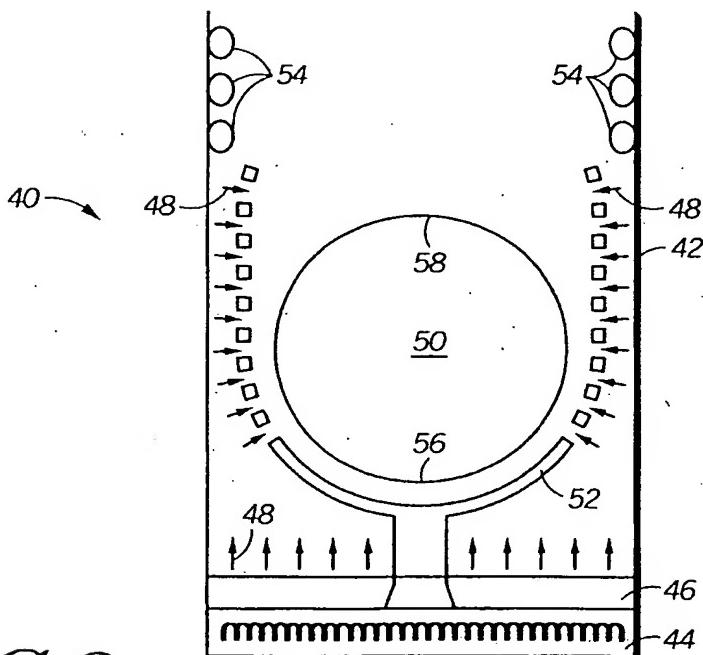


FIG. 2



European Patent
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EUROPEAN SEARCH REPORT

Application Number

EP 93 10 8329

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	PATENT ABSTRACTS OF JAPAN vol. 013, no. 088 (E-721)28 February 1989 & JP-A-63 266 833 (SAKURAI TOSHIHIKO) 2 November 1988 * abstract *	1,3,9	H01L21/00
A	---	5-8	
A	GB-A-2 224 639 (CANON KABUSHIKI KAISHA) * page 4, line 6 - page 6, line 9; figure 1 *	1,4-6	

TECHNICAL FIELDS SEARCHED (Int. CLS)			
H01L			
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	19 OCTOBER 1993	BOLDER G.	
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